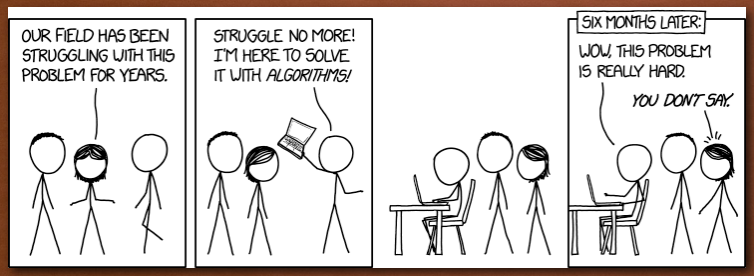
PROBLEM SOLVING



https://xkcd.com/1831/

LEARNING OBJECTIVES

- Examine some of the techniques used to solve problems
- The definition of an algorithm

PROBLEM SOLVING

- The Psychology of Problem Solving: https://www.youtube.com/watch?v=vg936IW9i7Q
  - problems such as these require "insight" i.e. they are not purely straightforward
  - many problems in computing require insight as well, but many are simple especially when you have seen similar examples previously
- George Polya "How to Solve It: A New Aspect of Mathematical Method"
  - Originally mathematical problems but general enough to apply to computing

HOW TO SOLVE IT

- https://en.wikipedia.org/wiki/How_to_Solve_It

1. Understand the problem
2. Make a plan
3. Carry out the plan
4. Look back on your work - could it be better?

1. UNDERSTANDING THE PROBLEM

- Questions that may be helpful:
  - Do you understand all of the terms in the problem?
  - Is there enough information in the specification to solve the problem?
  - Can you state the problem in your own words?
- If any of these are "No", then you need to ask questions
- Other things
  - Would a diagram help understand the problem?

2. MAKE A PLAN

- Lots of good ways to solve problems, and the more problems you solve the better you get
- Some strategies:
  - Guess and check
  - Make an orderly list
  - Eliminate possibilities
  - Use symmetry
  - Consider special cases
  - ...
- Also
  - Solve a simpler problem
  - Use a model
  - Work backward
  - ...

3. CARRY OUT THE PLAN

- Straightforward
  - but if the plan does not work go back to 2.

4. LOOK BACK ON YOUR WORK

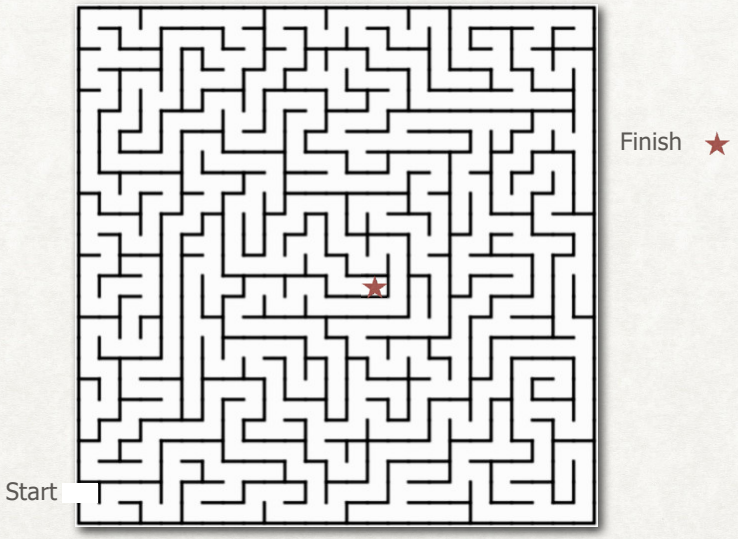
- This can help either to generalise your approach for similar problems
- or just to help you to understand what works for the future

EXAMPLE -SOLVING A MAZE

- The problem - Given a rectangular maze with one entrance you have to find your way to the centre of the maze.
- What further questions do you need to ask before you can produce an algorithm to solve this problem?

UNDERSTANDING THE PROBLEM

- How is the maze represented?
  - walls
  - paths
  - starting and ending points
- How do we perceive the maze?
  - bird's eye view
  - walking through the maze
- Would a diagram help?

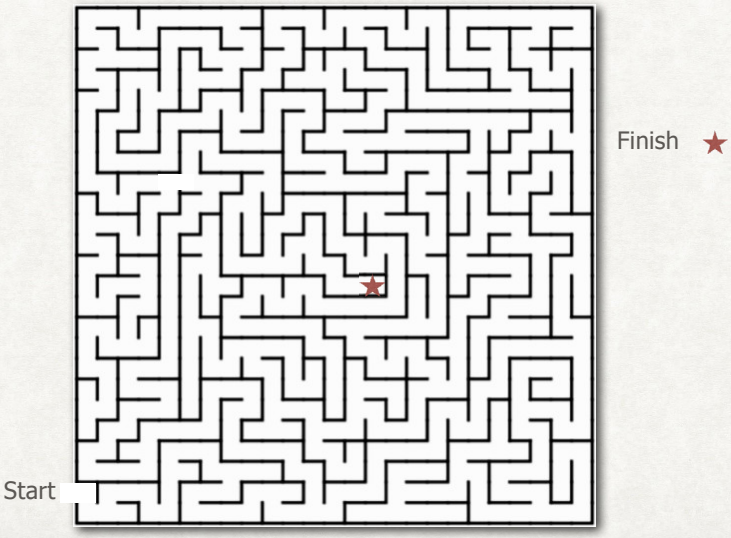


WE WANT TO SOLVE MORE THAN ONE MAZE

- We can start by examining how we can solve this one
- What would you do?
  - depth-first - https://www.youtube.com/watch?v=Les1Pttd3xg
  - wall following - https://www.youtube.com/watch?v=NA137qGmz4s
  - backwards
  - and of course bread crumbs (essential for many real solutions)
  - https://www.lesswrong.com/posts/CPBmbgYZpsGqkiz2R/problem-solving-with-mazes-and-crayon

DOESN'T WORK

- Say we chose left wall following as the technique - back to step 2



ALGORITHMS (1 OF 4)

- The Formal Definition of an Algorithm:
  - A well-ordered collection of unambiguous and effectively computable operations that, when executed, produces a result and halts in a finite amount of time

ALGORITHMS (2 OF 4)

- Well-ordered collection
  - Upon completion of an operation, we always know which operation to do next
- Unambiguous and effectively computable operations
  - It is not enough for an operation to be understandable, it must also be doable (effectively computable)
  - Ambiguous statements
    - Go back and do it again (Do *what* again?)
    - Start over (From *where*?)

ALGORITHMS (3 OF 4)

- Produces a result and halts in a finite amount of time
  - To know whether a solution is correct, an algorithm must produce a result that is observable to a user:
    - A numerical answer
    - A new object
    - A change in the environment

ALGORITHMS (4 OF 4)

- **Unambiguous operation**, or **primitive**
  - Can be understood by the computing agent without having to be further defined or simplified
- It is not enough for an operation to be understandable
  - It must also be *doable* (**effectively computable**) by the computing agent
- **Infinite loop**
  - Runs forever
  - Usually a mistake

WASHING HAIR ALGORITHM?

- From the back of a shampoo bottle

Step 1: Wet hair

Step 2: Lather

Step 3: Rinse

Step 4: Repeat

- What is wrong with this?

FIGURE 1.3 A CORRECT SOLUTION TO THE SHAMPOOING PROBLEM

Step	Operation
1	Wet your hair
2	Set the value of *WashCount* to 0
3	Repeat Steps 4 through 6 until the value of *WashCount* equals 2
4	Lather your hair
5	Rinse your hair
6	Add 1 to the value of *WashCount*
7	Stop, you have finished shampooing your hair

FIGURE 1.4 ANOTHER CORRECT SOLUTION TO THE SHAMPOOING PROBLEM

Step	Operation
1	Wet your hair
2	Lather your hair
3	Rinse your hair
4	Lather your hair
5	Rinse your hair
6	Stop, you have finished shampooing your hair

Which solution slide 18 or 19 do you prefer? Why?